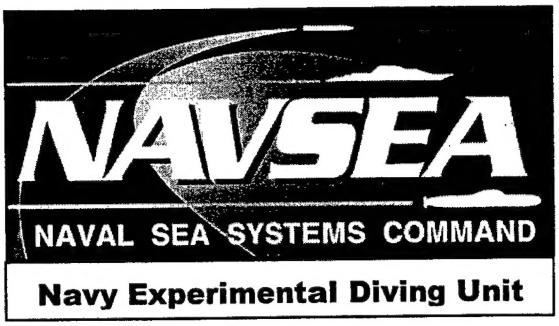
Navy Experimental Diving Unit
321 Bullfinch Rd.
Panama City, FL 32407-7015

NEDU TR 02-05
May 2002

AUTOMATED NEUROPSYCHOLOGICAL ASSESSMENT METRICS: NORMS FOR U.S. NAVY DIVERS



Authors: LT Michael Lowe, Ph.D.
CDR Dennis Reeves, Ph.D.

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING AUTHORITY	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Technical Report No. 02-05	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Navy Experimental Diving Unit 6b. OFFICE SYMBOL (If Applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 321 Bullfinch Road, Panama City, FL 32407-7015	7b. ADDRESS (City, State, and Zip Code)
8a. NAME OF FUNDING SPONSORING ORGANIZATION Naval Sea Systems Command 8b. OFFICE SYMBOL (If Applicable) 00C	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) 2531 Jefferson Davis Highway, Arlington, VA 22242-5160	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
		99-005b	

11. TITLE (Include Security Classification)
AUTOMATED NEUROPSYCHOLOGICAL ASSESSMENT METRICS: NORMS FOR U. S. NAVY DIVERS (U)

12. PERSONAL AUTHOR(S)
LT Michael Lowe, Ph.D. and CDR Dennis Reeves, Ph.D.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical Report	FROM _____ TO _____	2002 May	13

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
The Automated Neuropsychological Assessment Metrics (ANAM) was identified as a potentially useful screening instrument for assessing the cognitive abilities of divers. Normative data from 113 United States Navy divers were collected and are presented. The instrument is computer based and provides millisecond timing while automatically scoring and summarizing. It is purported to afford the level of sensitivity necessary for detecting cognitive problems that can result from diving, as well as central nervous system decompression sickness and oxygen toxicity. The instrument provides a good screening tool for suspected cognitive problems, and using it along with the other medical assessment tools is encouraged.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
[ ] UNCLASSIFIED/UNLIMITED [X] SAME AS RPT. [ ] DTIC USERS	Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
NEDU Librarian	850-230-3100	

DD Form 1473

CONTENTS

INTRODUCTION

The Automated Neuropsychological Assessment Metrics[1,2] (ANAM) is a computerized assessment software package currently used to assess various cognitive problems resulting from traumatic brain injury,[3,4,5,6] hyponatremia in U.S. Marine Corps recruits,[7] and aging in geriatric patients.[8] ANAM was also used to collect baseline information on the victims of the Chernobyl radiation exposure ten years after the accident.[9] While ANAM norms are established for other areas of cognitive study,[5,7,8] no norms are associated with using ANAM to identify potential cognitive problems that can affect U.S. Navy divers. Two of these problems include cognitive effects of central nervous system (CNS) decompression sickness (DCS)[10] and oxygen toxicity.[11,12,13] These problems may result following exposure to pressure and saturation environments[10,14] and are often exacerbated by concurrent exposures to challenging environments such as extreme cold or heat.

Navy Experimental Diving Unit (NEDU) Technical Report 93-01[15] provided a set of norms for a brief battery of traditional pencil-and-paper assessments. One of the drawbacks cited was that this battery of traditional pencil-and-paper tests typically required substantial time to administer, score and then interpret, because each battery consists of five or more tests, the required time increases drastically. There is, also another more important drawback to these traditional assessments with divers: they are apparently unable to detect cognitive decrements in personnel reporting symptoms after surfacing. Two factors may explain this: 1) there is no decrement or 2) the decrement is so subtle that the traditional batteries are not sensitive enough to detect it.

Naval Sea System Task Assignment 99-005B was initiated to identify and validate an instrument that might have the required sensitivity to screen for cognitive decrements when a diver manifests neurological symptoms. Computer platforms were explored because they were initially proposed as a means[15] to increase the precision of the instrument by eliminating the human-stopwatch interface, to automate the scoring process, and to markedly reduce the needed assessment time. The ANAM software[1,2] was chosen because it accurately measures reaction time to the millisecond, precisely measures the accuracy of correct responses, provides a measure of mental efficiency, and takes only approximately seven minutes to administer. This short administration time may make the instrument a useful tool in conjunction with standard neurological and physical examinations before, during, and after recompression treatments.

The ANAM software is a standard clinical subset of the Tester's workbench (TWB), of the Office of Military Performance Assessment Technology (OMPAT). The ANAM was developed from selected parts of the Unified Tri-service Committee Performance Assessment Battery (UTCPAB)[16] and the Walter Reed Performance Assessment Battery.[17] ANAM's development and composition are discussed in detail elsewhere.[1,2]

Because this tool is potentially useful, we sought to provide normative data tailored to U.S. Navy divers for guidance in making cognitive assessments of such subjects.

METHODS

GENERAL

Normative data were collected from diver-subjects taking part in various studies at both NEDU, Panama City, FL, and the Navy Submarine Medical Research Laboratory (NSMRL) in Groton, CT. Careful attention was given to ensure that data were obtained only once from each subject.

EXPERIMENTAL DESIGN AND ANALYSIS

The sample consisted of 113 U.S. Navy qualified divers with an average age of 33 and an age range from 20 to 50.

The data consisted of mean reaction time (Mean RT), the average response latency in milliseconds for the duration of each test; accuracy (% acc), the percentage of correct responses for each test; throughput (thruput), a measure of the number of correct responses made each minute (a measure then used as an index of mental efficiency);[2] and median reaction time (Median), a measure of the median response latency in milliseconds across all responses made during each test.

The data were compiled with the Statview feature of ANAM[2] and then transferred to Microsoft® Excel for analyses. Data analyses consisted of descriptive statistics that included mean, standard deviation, and range.

EQUIPMENT AND INSTRUMENTATION

The equipment consisted of Micron Transport Trek II laptop computers (Micron PC, 900 East Karcher Road, Nampa, Idaho 83687) with 366 Pentium processors, a standard mouse, and the ANAM software.

The tests in the ANAM battery were selected for assessing sustained concentration and attention; mental flexibility; spatial processing; cognitive processing efficiency; mood; arousal/fatigue level; and short-term, long-term, and working memory. Specifically, the ANAM battery that was used included the following subtests:[2]

- Demographics form
- Stanford Sleepiness Scale (measures alertness/fatigue level)
- Mood Scale 2-R (measures current mood level or state)

- Simple Reaction Time (measures basic psychomotor speed)
- Code Substitution (measures visual scanning and learning through letter/symbol comparison)
- Code Substitution with Long and Short Delay (measures immediate and delayed recall)
- Running Memory Continuous Performance Task (CPT) (measures working memory and executive functions)
- Mathematical Processing Task (measures computational speed and working memory)
- Matching to Sample (measures delayed recall/longer-term memory)

PROCEDURES

Each subject was presented with an environment that was controlled for aversive stimulation such as room temperature and sound. Most of the data was collected either in the morning or at the beginning of the subject's shift, if that subject was working a nonstandard shift. Each subject received a brief explanation of the battery before testing.

Baseline assessments were administered for the following studies:

- Accelerated Decompression (NEDU 1998-2000). This study sought to provide guidance for submarine escape by using pure oxygen during decompression. The ANAM was used to track central nervous system DCS.
- Deep Dive (NEDU 1998). The dive attained a storage depth of 1000 fsw; the ANAM was used in vivo to track depth-related changes in cognitive functioning.
- Warm Water Diving (NEDU 1999). This study examined the effects of diving in extremely warm water; the effects of heat exposure on cognitive performance were analyzed.
- Low Frequency Sound (NSMRL 1999). This study examined the effect of low frequency on nearby divers; the ANAM battery was used to track changes in cognitive functioning during exposure.

Only baseline (pre-exposure) data were used for the normative data.

RESULTS

Means, standard errors of the means, and related data for the 113 U.S. Navy divers are presented in the Tables of Appendix A. Although a small number of women was in the sample, all subjects were grouped together.
The labels, *run 1-1*, etc., refer to the specific session and run number within each session. For instance, *run 1-3* refers to the third run of any particular test during the first or only session.

Our sample of divers showed improvement in test performance and reduced variability with successive test administrations for Simple Reaction Time, Continuous Performance. The one exception was the math subtest, during which the divers performances decreased slightly from run 1-1 to run 1-2 for Mean RT, % acc, thruput, and Median. For all variables during run 1-3 the divers showed the expected improvements to those of run 1-1 and run 1-2.

DISCUSSION/CONCLUSIONS

Normative data sets have been established using the ANAM software for various populations such as individuals with varying degrees of traumatic brain injury (TBI)[3,4,5,6], geriatric patients[8], and people from the Chernobyl accident.[10] However, except for data from U.S. Marine Corps recruits, there is little information for relatively normal populations. Therefore, it was necessary to establish cognitive performance scores, based on a representative sample, of "normal" U.S. Navy divers. U.S. Navy divers are a unique group within the military family, as they are often exposed to challenging underwater environments. Though the results were characteristic for Navy divers, similar findings were obtained from a sample of United States Marine Corps (USMC) recruits.[7] Baseline performance data for ANAM is currently being established in the aviation community.

This normative data has clinical benefits, as it can afford guidelines for making treatment decisions involving any presentation of cognitive symptoms that result from central nervous system DCS, oxygen toxicity, and exposure to saturation environments. For instance, though it would be ideal for an individual's baseline performance to be in place as a marker for future assessments, this is not always possible. When this baseline is not available, normative data based on a representative sample of U.S. Navy divers could provide a guide for decisions.

If cognitive impairments are detected when ANAM is administered, then a more thorough assessment -- including traditional pencil-and-paper assessments if possible --should take place. ANAM should be administered in conjunction with other proven techniques such as the neurological and physical exams. ANAM may provide additional information that is useful and beneficial for diagnosis and treatment as well as for tracking recovery. Validation and reliability data are currently being analyzed and will be presented in a technical report at a later date.

REFERENCES

1. D. Reeves, R. Kane, K. Winter, and A. Goldstone, *Tester's Workbench Automated Neuropsychological Assessment Metrics (ANAM): Clinical and Neurotoxicology Subsets. User's Manual and Documentation*. Department of the Army, Office of Military Performance Assessment Technology, 1993.

2. D. Reeves, T. Elsmore, K. Winter, R. Kane, and J. Bleiberg, *ANAM 2000 (Beta 1.0) User's Manual.* NCRF/NRH Special Report 98-01. The National Rehabilitation Hospital (NRH), Washington, DC, 1998.

3. D. Reeves, J. Bleiberg, and J. Spector, "Validation of the ANAM Battery in Multicenter Head Injury Rehabilitation Studies," *Archives of Clinical Neuropsychology*, Vol 8, p. 262, 1993.

4. D. M. Levinson and D. L. Reeves, *ANAM V1.0 Normative Data*, Report No. NCRF-TR-94-01. San Diego, CA: National Cognitive Recovery Foundation, 1994.

5. D. M. Levinson and D. L. Reeves, *ANAM V1.0 TBI Norms*, Report No. NCRF-TR-95-01. San Diego, CA: National Cognitive Recovery Foundation, 1995.

6. D. M. Levinson and D. L. Reeves, "Monitoring Recovery from Traumatic Brain Injury Using Automated Neuropsychological Assessment Metrics (ANAM V1.0)," *Archives of Clinical Neuropsychology*, Vol. 12, No. 2, pp. 155-166, 1997.

7. E. Gastaldo, D. L. Reeves, D. M. Levinson, and B. Wenger, *ANAM USMC/95 Normative Data*, Report No. NCRF-TR-97-01. San Diego, CA: National Cognitive Recovery Foundation, 1997.

8. A. Goldstone, D. L. Reeves, D. M. Levinson, and M. Pelham, *ANAM V3.11 Geriatric Normative and CVA Data*, Report No. NCRF-TR-95-02, San Diego, CA: National Cognitive Recovery Foundation, 1995.

9. G. Gamache, P. Bidiouk, D. Levinson, D. Reeves, and F. W. Hegge, *ANAM-Ukraine Studies, Series I: Baseline Neurocognitive and Physical Assessments Ten Years after the Chernobyl Nuclear Accident*, Report No. NCRF-TR-97-03, San Diego, CA: National Cognitive Recovery Foundation, 1997.

10. M. D. Curley, "The Effects of Deep Saturation Diving on Diver Neuropsychological Functioning." Paper presented at the International Exchange Program (IEP) meeting, Portsmouth, England, 1988.

11. K. W. Donald, "Oxygen Poisoning in Man: I and II." *British Medical Journal*, Vol. 1, pp. 667-672, 712 - 717, 1947.

12. J. M. Clark, "Oxygen Toxicity." IN: P. B. Bennet and D. H. Elliot, eds., *The Physiology and Medicine of Diving and Compressed Air Work.* San Pedro, CA: Best Publishing Company, pp. 200-238, 1982.

13. M. D. Curley and G. J. Robin, "*Acute CNS Oxygen Toxicity and Diver Health.*" Paper presented at the International Exchange Program (IEP) meeting, Portsmouth, England, 1988.

14. T. G. Shields, B. Minaas, D. H. Elliot, and R. I. McCallum, eds., *Long Term Neurological Consequences of Deep Diving,* A. S. Verbum, Stavanager, Norway, 1983.

15. L. J. Crepeau, *Neuropschological Battery Development for Detecting Cerebral Decompression Sickness*, NEDU TR 1-93, Navy Experimental Diving Unit, 1993.

16. D. L. Reeves, K. P. Winter, S. J. LaCour, K. M. Raynsford, K. Vogel, and J. D. Grissett, *The UTC-PAB/AGARD STRES Battery: User's Manual and System Documentation*. NAMRL Special Report 91-3. Naval Aerospace Medical Research Laboratory, 1991.

17. D. R. Thorne, S. G. Genser, H. C. Sing, and F. W. Hegge, "The Walter Reed Performance Assessment Battery," *Neurobehavioral Toxicology and Teratology*, Vol. 7, pp. 415-418, 1985.

18. M. A. Lowe and D. Reeves. "At-depth evaluation of a computerized neuropsychological assessment tool: Deep Dive 98." Abstract in *Undersea and Hyperbaric Medicine*, Vol. 26, p. 18. June 1999.

APPENDIX A

ANAM DIVING NORMATIVE DATA

TABLE 1
ANAM Diving
Normative Data

Note: Mean RT is in milliseconds.

ANAM Diver Norms
Simple Reaction Time (Session 1-1)
Summary Statistics for Specified Measures

	Age	Education
MEAN	33	14
STD DEV	6	3
MEDIAN	33	13
MIN	20	12
MAX	50	24
N	105	113

ANAM Diver Norms (n = 113)
Simple Reaction Time (Session 1-2)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	269	78	100	228	253
STD DEV	0	47	151	0	31	29
MEDIAN	0	261	51	100	230	250
MIN	0	201	15	100	103	196
MAX	0	583	1520	100	299	345

ANAM Diver Norms (n = 113)
Simple Reaction Time (Session 1-1)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	286	87	100	221	265
STD DEV	0	104	182	0	35	75
MEDIAN	0	268	55	100	224	253
MIN	0	211	20	100	59	198
MAX	0	1016	1797	100	284	981

ANAM Diver Norms (n = 113)
Simple Reaction Time (Session 1-3)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	268	82	100	229	251
STD DEV	0	42	101	0	32	31
MEDIAN	0	261	60	100	230	249
MIN	0	207	16	100	127	199
MAX	0	473	891	100	290	339

ANAM Diver Norms (n = 112)
Continuous Performance Task (Session 1-1)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	1	624	173	92	90	616
STD DEV	0	96	40	13	19	114
MEDIAN	0	614	170	96	91	614
MIN	0	357	98	35	27	422
MAX	13	1123	318	100	130	1393

ANAM Diver Norms (n = 111)
Matching To Sample (Session 1-1)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	1772	692	91	32	1612
STD DEV	0	481	352	10	11	429
MEDIAN	0	1774	602	93	30	1603
MIN	0	709	139	40	10	680
MAX	1	3348	1725	100	85	3089

ANAM Diver Norms (n = 112)
Continuous Performance Task (Session 1-2)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	584	150	95	99	568
STD DEV	0	88	31	6	16	104
MEDIAN	0	576	150	96	100	561
MIN	0	427	80	65	38	404
MAX	12	1126	248	100	135	1361

ANAM Diver Norms (n = 113)
Matching To Sample (Session 1-2)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	1670	621	94	36	1515
STD DEV	0	448	310	6	12	384
MEDIAN	0	1654	546	93	34	1479
MIN	0	632	120	73	17	563
MAX	1	3166	1712	100	95	2754

ANAM Diver Norms (n = 112)
Continuous Performance Task (Session 1-3)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	562	143	96	104	546
STD DEV	0	83	34	6	18	94
MEDIAN	0	561	145	97	105	546
MIN	0	390	67	65	48	363
MAX	11	936	276	100	148	1149

ANAM Diver Norms (n = 113)
Matching To Sample (Session 1-3)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	1655	611	94	35	1515
STD DEV	0	431	298	7	10	388
MEDIAN	0	1598	536	93	35	1456
MIN	0	733	207	60	17	639
MAX	0	3217	1562	100	66	2679

ANAM Diver Norms (n = 113)
Mathematical Processing (Session 1-1)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	2573	897	95	24	2368
STD DEV	0	715	412	7	6	659
MEDIAN	0	2418	834	95	24	2269
MIN	0	1400	320	70	9	1331
MAX	1	5455	2414	100	40	5108

ANAM Diver Norms (n = 113)
Code Substitution
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	1296	473	97	47	1192
STD DEV	0	291	176	3	10	273
MEDIAN	0	1231	442	97	47	1156
MIN	0	729	204	88	25	667
MAX	0	2252	1081	100	75	2095

ANAM Diver Norms (n = 113)
Mathematical Processing (Session 1-2)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	2607	972	92	23	2413
STD DEV	0	720	494	8	6	669
MEDIAN	0	2435	847	95	22	2358
MIN	0	1126	315	55	10	985
MAX	0	4900	2588	100	39	4906

ANAM Diver Norms (n = 113)
Code Substitution Short Delay
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	1397	664	91	41	1198
STD DEV	0	382	397	9	13	308
MEDIAN	0	1335	577	94	40	1137
MIN	0	743	110	56	16	710
MAX	1	2962	1996	100	77	2410

ANAM Diver Norms (n = 113)
Mathematical Processing(Session 1-3)
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	2171	817	95	28	2007
STD DEV	0	579	420	6	7	528
MEDIAN	0	2095	734	95	27	1926
MIN	0	668	149	70	14	656
MAX	0	4163	2506	100	62	3769

ANAM Diver Norms (n = 113)
Code Substitution Long Delay
Summary Statistics for Specified Measures

	Lapses	Mean RT	St Dev	% Acc	Thruput	Median
MEAN	0	1368	711	88	40	1144
STD DEV	0	333	422	12	11	232
MEDIAN	0	1353	632	89	38	1123
MIN	0	712	148	44	13	662
MAX	2	2894	2082	100	84	2087